[Second Edition.]

PATENT SPECIFICATION

Convention Date (United States of America) : *Aug. 11, 1943.* **587,282**

Application Date (in United Kingdom) : *Aug. 11, 1944.* *No. 15372/44.*

Complete Specification Accepted : *April 21, 1947.*

COMPLETE SPECIFICATION.

Improvements in the Moulding of Hollow Bodies from Plastic

We, FORD MOTOR COMPANY LIMITED, of 88, Regent Street, London, W.1, a Company incorporated under the laws of Great Britain, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to methods of moulding plastics, particularly to the moulding or resin-impregnated materials to form light, strong cellular structures.

Generally, moulded plastics have been of the solid singular-walled type formed of moulding compounds or resin-impregnated material. These plastics were at first thought to be able to replace certain rigid materials, but they failed to meet physical requirements. To meet the requirement of strength, plastic mouldings were made of greater thicknesses, which disqualified them on their weight requirement. To meet the rigidity requirements, metal inserts or other rigid material such as wire gauze, thin electrically deposited metal sheets, or finely coiled wires were moulded in the plastic, but these were not entirely satisfactory.

It is therefore an object of this invention to provide a laminated plastic having greater strength per unit weight than other plastics having the same general composition. Another object of this invention is to provide a lightweight laminated plastic. Still another object of this invention is to provide a method by which the cellular forming means may be easily removed from the laminated structure. Still another object of this invention is to provide a method by which cellular structure may be moulded into complex curves.

An advantage of this invention is that large panels made as prescribed herein are substantially free from warping. Present, conventionally moulded plastic sheets, as small as one square foot, inherently warp unless warp-preventing means are incorporated in the body or moulded in such thicknesses that are several times normal. This warp-free feature, therefore, permits the use of plastics in wall panels, as a substitute for plywood (having greater strength at less density), in aircraft construction, and wherever light, strong, water- and warp-resistant plastics are adaptable.

The invention consists in a process of moulding a hollow cellular body from plastic which consists in arranging a plurality of rolls, each of which comprises a granular core enclosed in an impermeable tubular sheath which in turn is enclosed in an outer wrapping of resin-impregnated material, between outer laminated sheets of resin-impregnated material; subjecting the whole to heat and pressure, and subsequently removing the granular core.

In the accompanying drawings:—

Figure 1 is a perspective view of an element from which cellular objects are moulded.

Figure 2 is a perspective view of an assembled stack prior to the moulding operation.

Figure 3 is a perspective view of a finished moulded sheet.

Figure 4 is a cross-sectional view (on a larger scale) of Figure 3, showing the structure after moulding but before removing the core.

Figures 5, 6, 7 and 8 illustrate another method by which this said cellular structure may be assembled and the article made therefrom.

Figures 9, 10, 11 and 12 illustrate some of the possible combinations obtainable from the method disclosed.

In the production of large hollow cellular structures having considerable area, solid inserts or rubber inserts are not practical since the friction, the compacting of the plastic and complexity of design make their removal impossible. This is also true of rubber tubing in which pressure is maintained during the moulding cycle. Therefore, because of the foregoing reasons and since removal of solid inserts is impossible from mouldings having complex curved designs, such solid inserts may be only used in small, flat structures.

Moreover, it is readily seen that if a solid insert were used in the moulding of a structure of the type shown in Figure 3, the webbed reinforcing portion would

not be moulded under pressures equivalent to those under which the flat sections are subjected. This is apparent since the compressible material through the web has greater volume than material directly above and below the insert. During the moulding cycle the flat section will be, therefore, under full compression, while the web is only partially compressed. This results in a weakened web even though a portion of the resin becoming fluid under heat pressure flows from the flat section into the web. Also, the flat section may become weakened since there may be an excessive flow of resin from it to the web.

We have been able to overcome the above disadvantages with respect to pressure equalization during the moulding cycle and the subsequent removal of the inserts. In the drawings, several of the many possible combinations for increasing the strength of large-area, laminated plastics are shown. The structural strength is increased not only for compressive but also for flexural stress. Such increases are not directly proportional to the amount of stock used as in the case of solid-laminate moulding.

Referring to Figure 3, 10 is a laminated plastic body, (other examples are shown in Figures 9, 10, 11 and 12, and these are formed under similar conditions utilising several variations of structural design), having a flat surface 11 and a web structure 12 forming the hollow chambers 13. The hollow chambers 13 may assume various shapes as shown; they may be positioned in multilayers and at various angles to each other; they may be moulded in various curvatures; or they may be irregular in shape such as may be found in an air-foil section, etc.

The laminated plastic 10 is moulded from a stack 14 (Figure 2) which is composed of rolls of resin-impregnated materials 15 in juxtaposition in between the flat sheets 16 which are also impregnated with resin. The resin-impregnated materials may be one of those taken from the group including natural and artificial fibres, fabrics, paper and other materials known to the art.

The roll 15 is composed of a mandrel 17 (Figure 1) consisting of a core 18 of granular material within a tubing or rolled sheath 19 around which is wound impregnated material 20. These rolls may be formed in various geometric shapes; some of these may or may not be altered during compression due to the equalization of pressures. This is illustrated in Figures 9 and 10. In the former the triangular tubes retained their original shape, but in the latter the round tubes have been displaced substantially as shown.

The stack 14 is placed between heated platens 21, or moulding dies of a hydraulic press as shown in Figure 7, and subjected to heat and pressure.

Pressure, temperature and time are the variables, dependent on the resin. Therefore, since hollow bodies as shown herein may be formed from many resins, these variables are optional to the operators. The use of resins moulded under low pressures is desirable in production of large area panels making available the employment of lower pressure equipment. However, sufficient pressure insuring complete compacting and bonding of the resin and fibres is important. Our moulding procedure has been successfully accomplished when pressures of about 50 to 800 pounds per square inch were employed.

The mandrel 17 is formed by filling a tube or sheath 19 with granular, non-packing materials. These tubes may be extruded tubes, for example, of cellulosic material, or tubes formed by rolling sheet stock of material known under the Registered Trade Mark "Cellophane", sized paper and the like. It is important, however, that the sheathing thus made be impermeable since otherwise the flow of resin into the granular core will bind the core, thereby hindering its removal from the finished laminate. The tubes are sealed at the ends by either folding the ends tightly and fastening them to the main portion of the tube body or by using resilient plugs which are inserted into the ends and held in place during the moulding cycle by retaining means attached to the platen.

For the removable core material we choose to use sand but, however, fine metal shot, diatomaceous earths, salts and the like are also suitable. Such materials must be free from packing in order to be capable of fluid-like displacement so that the internal webs may be moulded under the same pressure as the external parts. These features of non-packing are especially important in large and bulky curved units which are moulded under considerable pressure and from which the core material is ejected by means of an air-blast or vibrating equipment. The removal of sand is very readily accomplished, not requiring special equipment; and in most instances it is removed from that end of the plastic which is trimmed to remove the rough and uneven deposit of resin that is exuded during compression.

Plastics moulded by this method are characterised by their substantially uni-

form cavities having slight radii rather than sharp corners. This is shown in Figure 4 in which the compression of fabric and the dispersion of resin is uniform; also the core material and its sheath has been displaced to substantially a rectangle from a circular tube.

An expedient of this invention is the increasing of internal compression pressure by adding to the core mix certain compounds such as ammonium carbonate which under heat will decompose, forming gases, thereby increasing the internal pressure. It has been found that only a small amount of ammonium carbonate is necessary and in many instances from 1 to 5 per cent. by weight of the core material has been found suitable.

Another expedient effecting a faster cure of resin while moulding under our method has been to incorporate metallic powders in the core mix so that heat may be generated internally by means of high-frequency current. This is especially useful in large, multilayer mouldings in order to reduce the moulding cycle, as the transfer of heat is very slow from platens to the centre of the moulding charge.

Another method which may be employed for carrying out this invention involves quilting of the material enclosing the sand core, as shown in Figures 5 to 8. Figure 5 discloses the initial steps of the operation in which a suitable number of layers of resin-impregnated material 20 are sewn together, having two sheets of impermeable material 19 therebetween. Sand or other material is injected between these layers, compacted and sewn, as shown in Figure 6. Such quilting may be easily carried out with the equipment that has been developed in the various arts relating to filling and sewing. However, it is not necessary that the quilting be done in any particular shape having perfect symmetry, but rather it is desired that uniform compactness of the material be maintained. The above-described sand-filled quilt is placed between outer sheets 16 and then moulded between either dies or platens which may or may not have complex curvatures. It is important, however, that this type of material be used in dies which are complementary to each other: namely, those that will not impart a draw to the article. Figure 7 shows the quilted roll of Figure 6 disposed between outer flat sheets 16.

In the foregoing method of preparing a stack for moulding, it has been found necessary, at times, to apply a sealing compound along the perforations of the seams to prevent seepage of resin into the core. It is commonly known that like resins are used in plastic mouldings that are used in the binding of abrasives, and for this reason resin must be kept removed from the core if normal removal of core is to be expected.

Impermeable materials in order of paper, cellulosic films, and the like have been found suitable for sheaths for comminuted core materials. These may be seamless, spiral wound, or overlapped, multilayer types. Regardless of the type, mechanical equipment is obtainable in order to facilitate production and to compete with conventional moulding processes. These sheaths are made in shapes and forms which are, substantially, sections of the finished article. In this manner various contours are produced in the finished moulding. As an example, if gradually tapering (in one or more directions) forms are employed, an air foil section may be moulded. However, the moulding dies must have surfaces corresponding in shape to those of the finished article.

Tests on panels moulded according to our method show a marked, increased strength over those of straight or solid laminated moulding. As a basis of comparison, these tests are taken on a unit—weight—area relationship so that equal amounts of resin, cloth, and the like can be readily compared. Tests strips are tested both for flexural strength and for compressive strength. The flexural test consists of placing a test strip on two separated supports while a third support is brought to bear on the plastics in the opposite direction. Pressure is then slowly applied until failure occurs and the pressure accordingly recorded.

Plastics as moulded by our method are found to be far superior both in a transverse and longitudinal strength to conventionally moulded plastics containing equal amounts of resin, fabric, etc. differing only in volume due to the method of moulding. The increase in strength in the longitudinal direction has been in excess of four times that of the conventional plastic, while the transverse strength has been increased in excess of twice. This variation is to be expected since the panel longitudinally is reinforced by the web forming an **I**-beam construction.

Under compression tests our plastic cannot be compared with conventionally moulded plastics which are extremely flexible unless moulded in heavy sections, but on a weight basis, approaches the compression strength of aluminium having a similar construction. However, since the aluminium is extremely difficult to fabricate in the same shape and

size as that of our plastic, it was necessary to use a single flat sheet and rivet to it conventional reinforcing members.

In comparison with wood, our plastic under compression has a higher modulus while possessing a much lower density. As an example hickory has a modulus, representative of the hard woods, of about 9,000 pounds per square inch and a density of about .026 lbs./in.^{3}, while our plastic has a modulus of about 15,000 pounds per square inch and a density of about .017 lbs./in.^{3}.

From the foregoing examples it is readily seen that some changes may be made in the arrangement, construction and combination of the process and article without departing from the scope of the invention.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A process of moulding a hollow cellular body from plastic which consists in arranging a plurality of rolls, each of which comprises a granular core enclosed in an impermeable tubular sheath which in turn is enclosed in an outer wrapping of resin-impregnated material, between outer laminated sheets of resin-impregnated material, subjecting the whole to heat and pressure and subsequently removing the granular core.

2. A process according to claim 1 in which the impermeable material consists of sized paper.

3. A process according to claim 1 in which the impermeable material consists of cellulosic film.

4. A process according to claim 1 in which the granular core is encased between outer sheets of impermeable and resin-impregnated materials, and the rolls formed by quilting said outer sheets.

5. A moulded hollow article having supporting members therein forming a cellular structure, said supporting members having been moulded under pressure substantially the same as exerted on the surface of said hollow article, said hollow article being formed by a process substantially as claimed in claim 1, 2, 3, or 4.

6. A process for moulding hollow cellular articles substantially as herein described.

7. Hollow moulded cellular articles produced by the processes claimed above.

Dated this 11th day of August, 1944.
MARKS & CLERK.

Abingdon: Printed for His Majesty's Stationery Office, by Burgess & Son.
[Wt. 8268A.—12/1947.]

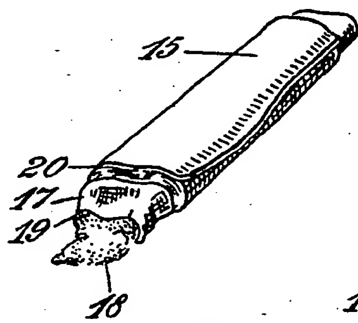
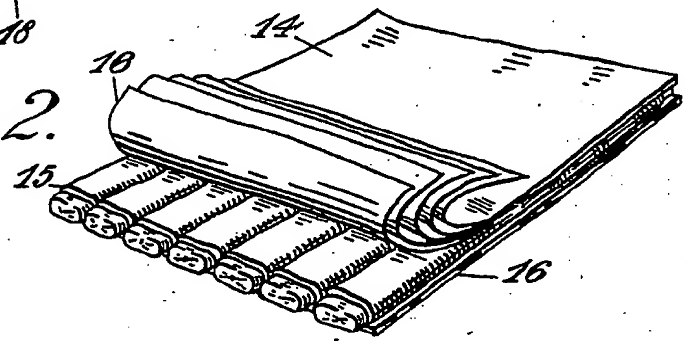


Fig. 1.

Fig. 2.



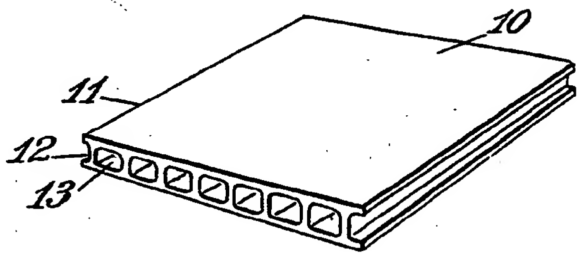


Fig. 3.

Fig. 4.

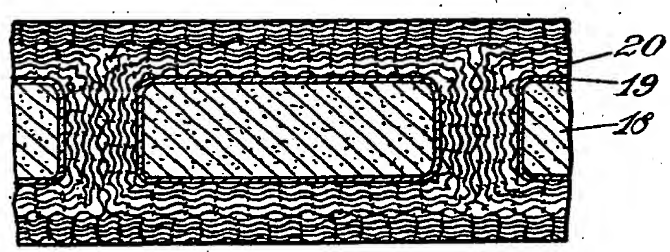


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Fig. 5.

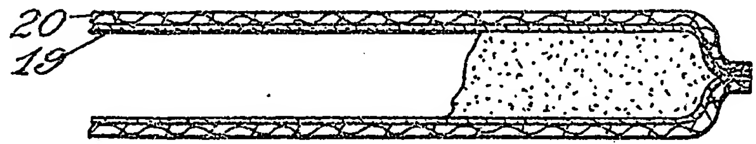


Fig. 6.

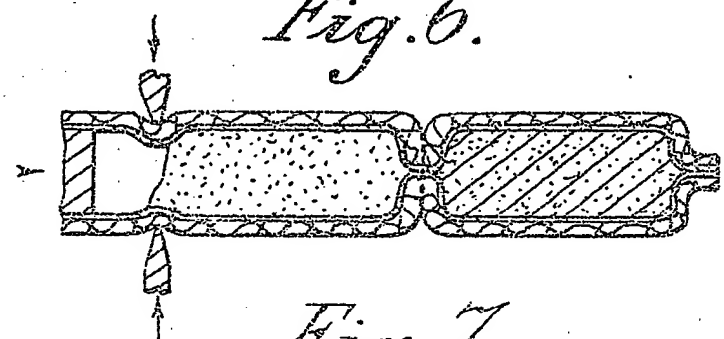


Fig. 7.

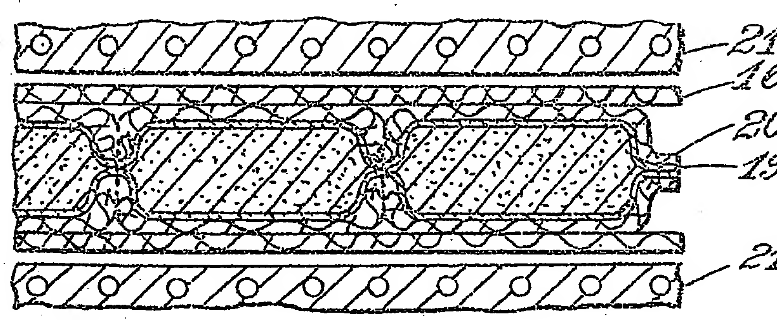
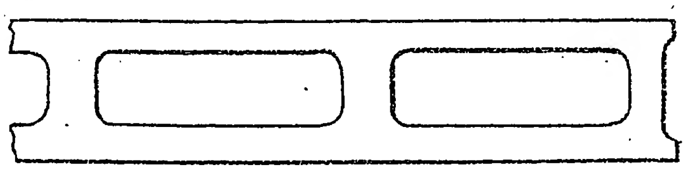


Fig. 8.



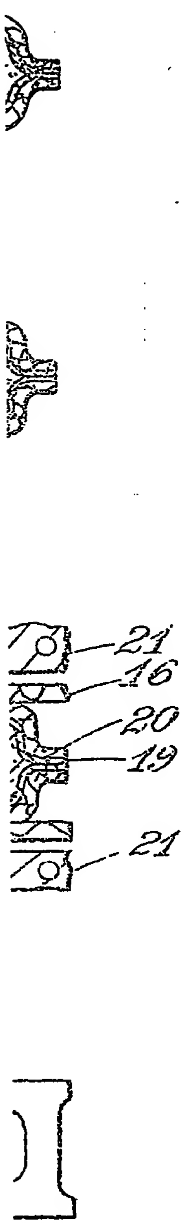


Fig. 9.

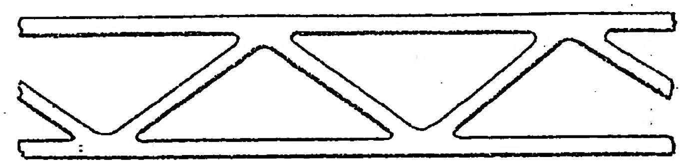


Fig. 10.

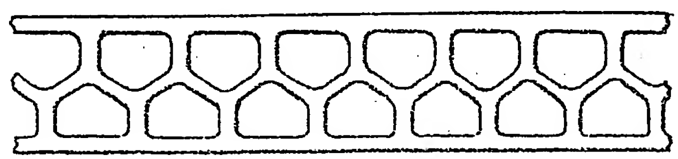


Fig. 11.

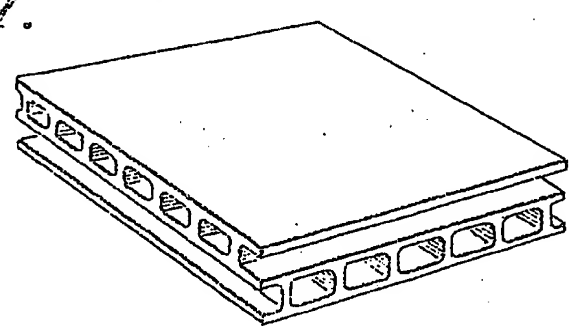
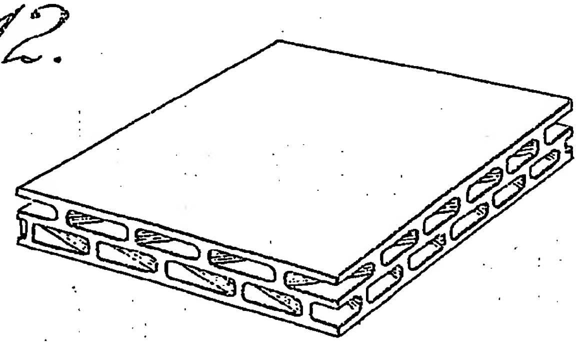


Fig. 12.



H.M.S.O. (Ty. P.)

587,282 COMPLETE SPECIFICATION
2nd Edition

3 SHEETS
SHEET 2

Fig. 5.

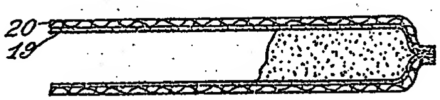


Fig. 6.

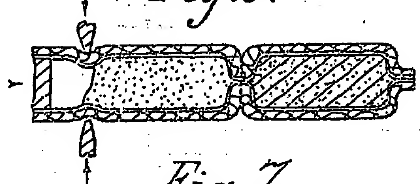
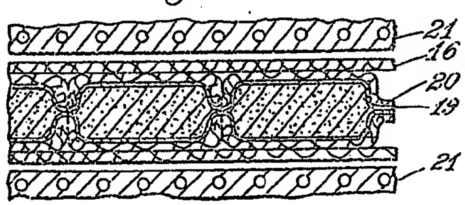


Fig. 7.



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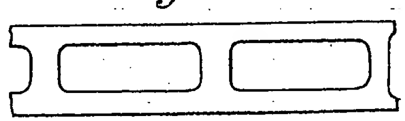


SHEET 3

Fig. 9.

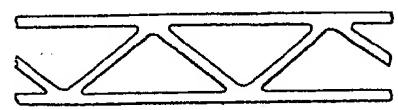


Fig. 10.

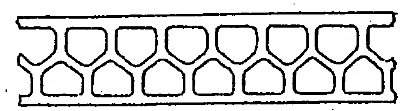


Fig. 11.

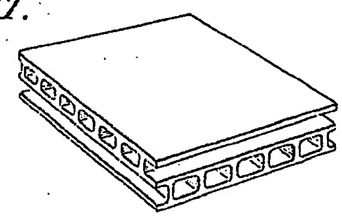
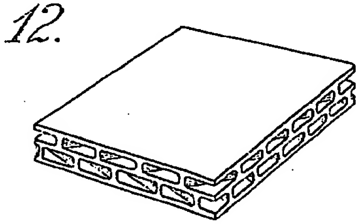


Fig. 12.



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